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# PECULIARITIES OF SUNFLOWER DISEASES DEVELOPMENT IN THE LEFT-BANK FOREST-STEPPE OF UKRAINE

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***Abstract***

*The article presents the results of research conducted in 2023 on the basis of the Dokuchaevske Experimental Field of the State Biotechnology University. The aim of the work was to study the complex of fungal pathogens of sunflower and to investigate the dynamics of the most harmful of them in the conditions of the Left-Bank Forest-Steppe of Ukraine. The instability of weather conditions in the Left Bank Forest-Steppe (heavy short-term showers alternating with drought) and violation of agricultural practices (non-compliance with crop rotation, sowing dates, unsuccessful predecessors, etc.) lead to sunflower diseases of different etiology. The time of occurrence and the degree of development of the disease is determined by the meteorological conditions of the year, the timing of sunflower sowing and the biological characteristics of the fungi themselves. The study of the development of fungal diseases of sunflower showed that the most harmful and widespread diseases during the study period were: rust (Puccinia helianthi Schw.), downy mildew (Plasmopara helianthi Novot. f. helianthi), phomopsis stem canker (Phomopsis helianthi Munt. Cvet. et al.).*

***Key words****: sunflower, diseases, crop rotation.*

## INTRODUCTION

The expansion of the areas under sunflower cultivation is contributing to the accumulation of a large number of pests in the fields. This necessitates the search for ways to significantly intensify sunflower production and study the species composition of pests for a particular soil and climatic zone (Markov, 2017; Vigera, 2009). Diseases are a significant factor that limits high sunflower yields. Regional differences in climate, the spread of microbial pathogens, and crop cultivation technology can impact the development and prevalence of certain diseases. It is important to consider these factors when studying disease patterns (Jocic et al., 2015; Markell et al., 2015; Melnychuk et al., 2020).

The weather conditions in the Left Bank Forest-Steppe are unstable, with heavy short-term showers alternating with drought. This instability, combined with violations of agricultural practices such as non-compliance with crop rotation, sowing dates, and unsuccessful predecessors, leads to sunflower damage from diseases of various etiology (Chuiko, 2021; Dehtiarova et al., 2022; Dehtiarov, 2023). It is important to note that this is a purely objective evaluation of the situation. Sunflowers can be affected by over 20 species of pathogens, with the main ones being phoma black stem (*Phoma macdonaldii* Sacc.), phomopsis stem canker (*Phomopsis helianthi* Munt. Cvet. et al.), rust (*Puccinia helianthi* Schw.), downy mildew (*Plasmopara halstedii* Novot), white rot (*Sclerotinia sclerotiorum* (Lib.), and grey rot (*Botrytis cinerea* Pers.) (Gulya et al., 2002).

In recent years, there has been a general trend of changes in the composition of the phytopathogenic complex of field crops due to the widespread introduction of short-term crop rotations with higher payback and a reduction in the range of crops grown (Govorun et al., 2015). In Ukraine, crop rotations are specialised in three main areas: growing grain, oilseeds and fodder crops. Simplifying crop rotations without considering traditional basics and rules can lead to the spread of specialized weeds, pests, and diseases. This is despite the increasing use of chemical protection products. (Shuvar et al., 2015). It has been discovered that the number of weakly pathogenic species of diseases, known as polyphages, has increased. These diseases are commonly found in most cultivated plants. (Petrenkova et al., 2013). There is a tendency for coal rot to increase, which is a disease that can affect any crop due to the rapid accumulation of a long-term soil infection (Borovska and Sokol, 2015). To implement the concept of integrated plant protection, it is essential to collect information on the number and state of the pest population. This information is used to assess the phyto-sanitary condition of the field and region. This information provides a basis for justifying the use of chemicals, determining the pathogenic composition of phytocontrol agents, and assessing the state of the population, including their variability in long-term observations. (Kuleshov et al., 2011; Yevtushenko et al., 2004).

## MATERIALS AND METHODS

The study was conducted in 2023 at the Dokuchaevske Experimental Field Training and Research and Production Centre (TRPC) of the State Biotechnological University. This year, the air temperature deviated significantly from the long-term average in March (+7.1°C) and June (+2.1°C). The largest amount of rainfall was recorded during the spring and summer months, with May (119.1 mm), June (132.8 mm) and July (170.3 mm) experiencing the highest levels of precipitation. These months recorded rainfall levels of 70.1, 73.8, and 99.3 mm above the long-term average. The sowing plot measures 750 square metres, while the accounting plot measures 100 square metres. Plots are located sequentially Sunflower cultivation technology is generally accepted in the research area. The sunflower hybrid, LG 59580, was sown at a seeding rate of 68,000 units per hectare.

Disease assessment was conducted on 40 plants in 10 plots arranged in a single row at 10 equidistant locations along two diagonals of the field. The number of plants affected by each disease was counted separately. For the stem and root forms of white rot, downy mildew and verticillium wilt, only disease incidence (% of plants affected) was assessed. For the assessment of the intensity of the disease manifestation, a conventional disease-specific scale was used (Kirichenko et al., 2007):

0 - up to 10% of the plant surface (organs) are infested; 1-11 to 25% of the plant surface (organs) are affected; 2-26 to 50% of the plant surface (organs) are affected; 3 - over 50% of plant surface (organs) affected.

To determine the degree of rust damage, a different scale was used: 0 - healthy plants; 1 - isolated pustules on the whole plant; 2 - separate groups of pustules on the leaves, more severe damage on the underside; 3 - numerous pustules, sometimes merging, on the leaves of the middle layer; 4 - continuous development of large pustules on the leaves of the middle layer, which merge.

The spread of the disease was determined by the formula below:

$$F = \frac{n \times 100}{N} \quad (1)$$

where: F - the frequency of attack, %; n - number of diseased plants in the sample (or individual organs); N - total number of plants (individual organs) examined.

The degree of disease development was determined by the formula:

$$AD = \frac{\sum (a \times b)}{N \times k} \times 100 \quad (2)$$

where: AD - attack degree, %; $\sum(a \times b)$ is the sum of the products of the number of plants and the corresponding damage score; N - the total number of plants in the survey; k - the highest score of the accounting scale.

Statistical data processing was performed using the Microsoft Excel analysis package.

## RESULTS AND DISCUSSIONS

The increase in sunflower area and its repeated cultivation in the same field leads to an accumulation of crop residues in the fields and an increase in weed infestation. These factors contribute to the spread of diseases and pests. Protecting the sunflower crop is therefore an important element of sunflower cultivation technology. To reliably protect sunflowers from disease, you need to follow the basic rules of crop production and understand the biology of not only the plant, but also the pathogen itself. The sunflower plant can be affected by more than 20 different types of fungal pathogens. The study of the development of fungal diseases of sunflower showed that the most harmful and widespread diseases in the conditions of the Left-Bank Forest Steppe of Ukraine during the study period were: rust (*Puccinia helianthi* Schw.), downy mildew (*Plasmopara helianthi* Novot. f. *helianthi*), phomopsis stem canker (*Phomopsis helianthi* Munt. Cvet. et al.).

The timing and degree of development of the disease caused by a particular pathogen is largely determined by the meteorological conditions of the year, the timing of sunflower sowing and the biological characteristics of the fungi themselves. Identifying the dependence of the development of diseases on hydrothermal conditions revealed the ambiguity of their manifestation. High moisture is known to contribute to plant infection and pathogen development, and unfavourable conditions tend to limit the development of fungal diseases. However, if the development of the disease has reached a high level during the period assessed as dry, this is due to the presence of drip moisture, such as morning dew, which appears due to the difference in night and day temperatures, the duration of retention of this moisture on the leaf surface, the duration of the period of high air humidity after precipitation, the specifics of plant architecture, the density of plants in the crop, where a microclimate is formed that is favourable for the germination of fungal spores.

The increase in air humidity against the background of moderate temperatures causes a high level of spread and development of grey rot on sunflower. The coincidence of the critical period of plant development with prolonged soil and air moisture means that the downy mildew pathogen can spread rapidly in the case of diffuse damage in the early stages of development. Even regular short-term precipitation is enough for the pathogen to infect and cause secondary infection. Phomopsis development reaches a high level even in a dry month if the previous months were optimal and waterlogged.

In our studies, the weather conditions of the sunflower growing season in 2023 were characterised by significant variability, with fluctuations in the hydrothermal coefficient (HTC) ranging from 0 in September to 0.9 in May (Table 1).

Table 1. Fluctuations in the HTC during the sunflower growing season, 2023

| | Months/phases of the sunflower growing season | | | | | |
|---|---|---|---|---|---|---|
| | May (sowing-leaf emergence) | June (basket formation) | July (flowering-seed formation) | August (seed filling) | September (physiological and technical seed maturity) | Average HTC for the growing season of sunflower |
| | 0.9 | 0.8 | 0.8 | 0.3 | 0.0 | 0.5 |
| Multi-year average HTC | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |

Notes: HTC < 0.4 - very severe drought; HTC 0.6 to 0.7 - moderate drought; HTC 0.8 to 0.9 - mild drought; HTC from 1.0 to 1.5 - adequately wet; HTC > 1.5 - excessively wet.

Due to the close dependence of the variability of Phomopsis on the hydrothermal conditions of the year, it is better characterised by a qualitative indicator of damage – the intensity of disease development, which is determined by the weighted average area of the affected stem surface. In turn, to describe this indicator, we need to analyse the HTC for each month of the crop's growing season, which practically coincides with the duration of the crop's developmental stages. Thus, unfavourable conditions (mild drought for sunflower from May to July and very severe drought from August to September) contributed to the low intensity of phomopsis stem canker development. The maximum incidence was only 1.4% (Table 2). Due to the oversaturation of the crop rotation with sunflower in hot conditions during the seed ripening period, an epiphytic level of rust (*Puccinia helianthi* Schw.) manifestation was observed - 75.8%. In August, conditions were somewhat favourable for the development of downy mildew, with a rate of 10.3-12.3%.

**Downy mildew** (*Plasmopara helianthi* Novot. f. *helianthi*). In sunflower, the disease appears at the end of the seed filling period and is generally not considered a serious threat in temperate regions. If the infection is limited to leaves that are removed before marketing, the impact is reduced, but downy mildew downy mildew can also develop on stems and baskets (Gulya et al., 2002).

Table 2. Dynamics of the development of fungal diseases on sunflower crops

| The disease | Date of examination | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 19.07 | | 26.07 | | 10.08 | | 25.08 | | 23.09 | |
| | **F** | **AD** | **F** | **AD** | **F** | **AD** | **F** | **AD** | **F** | **AD** |
| Downy mildew | 3.2 | 0.1 | 7.7 | 0.5 | 37.3 | 12.3 | 25.2 | 10.3 | 10.5 | 5.4 |
| Rust | 10.6 | 2.4 | 35.7 | 11.8 | 70.6 | 37.9 | 100.0 | 50.7 | 100.0 | 75.8 |
| Phomopsis stem canker | — | — | — | — | 2.5 | 0.7 | 3.2 | 0.8 | 4.5 | 1.4 |

Notes: F- the frequency of attack, %; AD - attack degree, %.

The first downy mildew infestation in 2023 was detected in the 8-10 true leaf stage on some plants. The plants lagged behind in growth and development, had shortened stems and underdeveloped internodes, leaves were wavy, covered with chlorotic spots on the upper side and white spore formation on the lower side (Figure 1).

Figure 1. Sunflower plants affected by downy mildew (*Plasmopara helianthi* Novot. f. *helianthi*)

**Rust** (*Puccinia helianthi* Schw.). In 2023, there was a significant amount of rust damage to the sunflower crop. The first symptoms of the disease appeared at the stage of 3-4 pairs of true leaves. They took the form of yellow-orange convex spots. On the upper side of the leaves, spherical spermogonia were formed on the spots, and on the lower side - orange aecidia, close together. As of 10.08.2023 (flowering phase), as a result of sunflower infection with aecidiospores, rusty brown pads - uredopustules with uredospores - developed on the underside of the leaves (Figure 2).

During the growing season, the fungus can produce several generations of uredospores, which promotes the development of the disease. At the stage of seed filling, separate groups of pustules appeared on all plants, and the disease spread reached 100%. The intensity of the disease increased rapidly and reached 3 points in the yellow basket phase.

Figure 2. Sunflower plants affected by rust (*Puccinia helianthi* Schw.)

**Phomopsis stem canker** (*Phomopsis helianthi* Munt. Cvet. et al.). Phomopsis stem canker, a fungal disease caused by *Phomopsis helianthi* Munt. Cvet. et al. Stem canker has become one of the most limiting factors for oilseed yields worldwide (Mathewet et al., 2015; Gulya et al., 2018). The appearance of phomosis stem canker, a fungal disease caused by *Phomopsis helianthi* Munt. Cvet. et al. Stem canker has become one of the most limiting factors for oilseed yields in the second half of the growing season leads to a reduction in plant productivity and a deterioration in seed quality. Crop losses can be up to 25% (Shishkin, 2022). The disease is extremely harmful and, under favourable conditions (sufficient moisture and heat), spreads rapidly aerogenously, leading to devastating consequences. Plants can be affected by phomopsis stem canker from the two true leaf stage until the end of the growing season.

The INRA-Cetiom collaboration in the Toulouse region has experimentally studied the effect of sunflower cultivation on the frequency and intensity of Phomopsis infection. It has been shown that sowing density increases the proportion of stems with *Phomopsis* spots. On the other hand, under certain conditions, increasing the nitrogen dose can reduce the incidence of stem damage. Delayed sowing reduces the risk of leaf infection and stem damage (Debaeke et al., 2003). In oilseeds production, foliar fungicides are used to prevent leaf infection, but current management practices rely more on genetic resistance and crop management. Other management tools include cultural practices (reduced plant density, reduced nitrogen fertilisation, crop rotation) that minimise the potential for Phomopsis infection (Debaeke et al., 2003). Although *Phomopsis helianthi* Munt. Cvet. et al. and other sunflower pathogens were thought to be host-specific, recent evidence shows that they can infect and survive on weeds and other hosts, both living and dead plants (Thompson et al., 2015). Crop rotation will therefore be of limited benefit, but the eradication of weeds and wild sunflowers in fields will potentially reduce the amount of seed available. Burying plant residues to a depth of at least 5 cm will accelerate plant decomposition and expose *Phomopsis helianthi* Munt. Cvet. et al. to biodegradation.

In the research field, the first infection of plants with Phomopsis was observed in the budding phase - at the beginning of sunflower flowering. Necrosis with a chlorotic border appeared on the lower leaves, starting at the tip of the leaf and spreading along the main vein, leading to desiccation. Rounded, elongated, grey-brown spots formed near the affected petiole (Figure 3).

There was no significant development of the disease during the study period due to the lack of rainfall and hot weather. Disease incidence did not exceed 5% and development 1.4%. No stem breakage was found as a result of pathogen damage.

Figure 3. Damage of sunflower plants by Phomopsis (*Phomopsis helianthi* Munt. Cvet. et al.).

## CONCLUSIONS

The study analysed the prevalence of fungal diseases in sunflowers in the Left-Bank Forest-Steppe region of Ukraine. The most common diseases during the study period were sunflower rust (*Puccinia helianthi* Schw.), downy mildew (*Plasmopara helianthi* Novot. f. *helianthi*), and phomopsis stem canker (*Phomopsis helianthi* Munt. Cvet. et al.). Rust was the most threatening to the crops (with 100 per cent of affected plants, the intensity of sunflower damage was 4 points on a five-point scale). The main harmfulness of rust (*Puccinia helianthi* Schw.) is: loss of sunflower nutrients (approximately 15%) for the formation and sporulation of the fungus, reduction of the basket size by 8-16%, reduction of seed yield by 15-40%, reduction of the assimilation surface of leaves, premature drying of leaves, deterioration of seed quality (reduction of oil content from 4% to 15%). During the second phase of plant vegetation, the absence of precipitation prevented the development of phomopsis. The damage caused by phomopsis stem canker did not exceed 43.5% and 30%, respectively.

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